

# Explaining Northern Michigan Snow (A "Big Picture" Viewpoint)



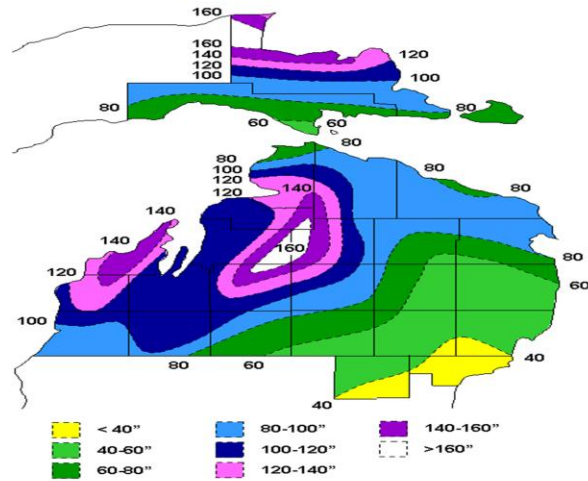
2010 Winter Talk Series

## Background

- If you've attended our Winter Talk series in the past, there's a good chance you've seen us discuss the science of *lake effect snow*
- Lake effect snow is the single most important factor as to why some parts of Northern Michigan get so much more snow than others

We won't rehash those previous talks TOO much, but we will talk about some of the same topics from a somewhat different angle.

## Mean Annual Snowfall NWS Gaylord Forecast Area



So: why does this map look like this?

In this presentation we will try to answer why our mean annual snowfall map has the pattern it does.

## **Not to give away the answers, but...**

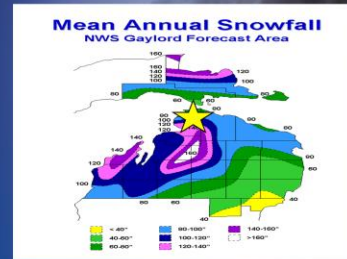
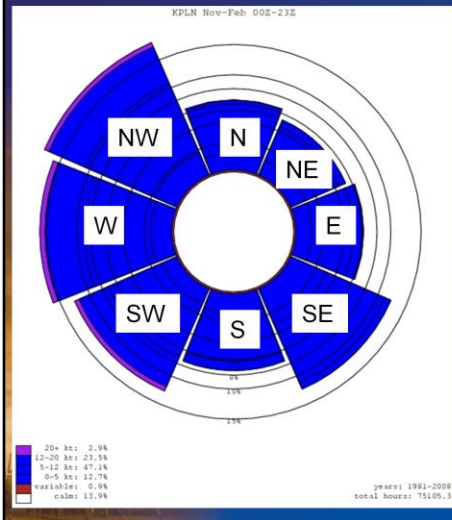
- **Prevailing wind direction during cold air outbreaks**
- **“Fetch” and “effective fetch” lengths**
- **Elevation**
- **Proximity to a “warm” lake**
- **Ice cover**

Here are some of the reasons that we will examine throughout this presentation.

## Prevailing Winds

- Lake effect snow will tend to develop over the Great Lakes, as long as the air is cold enough, and the water is warm enough
- Where the snow goes from there, depends on where the wind is blowing
- Thus, the “prevailing wind” – our most common wind direction – during periods of cold weather is crucial

# Prevailing Winds



- Wind Rose for Pellston, MI (Nov-Feb)
- Dominance of Northwestern direction
  - *Particularly when cold air is arriving!*

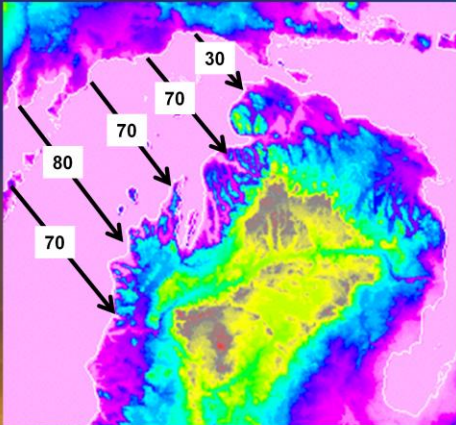
The plot on the left shows a wind rose of all wind reports from Pellston for the November-February period. You can see that, for a majority of the time, the prevailing winds are West or Northwesterly, particularly when cold air is arriving.



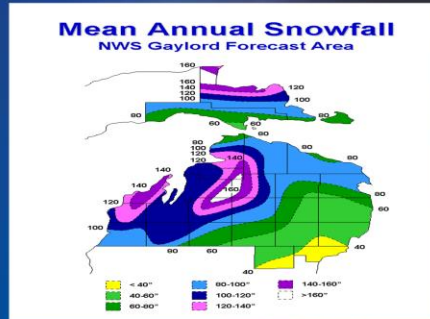
## Prevailing Winds & Fetches

- A “fetch” is the distance over which air is moving over water, for a given wind direction
  - *Generally speaking, the longer the fetch, the more snow the lake will be capable of generating*
- Given that a northwest wind is our prevailing winter wind, what kind of fetch does that produce?

# Prevailing Winds & Fetches



- The longest fetch, and heaviest snow, do NOT match up.



- So is there something we are we not accounting for?

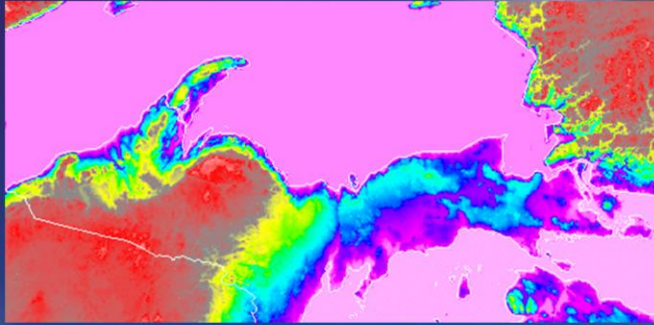
The figure on the left shows the fetch for a northwesterly wind over northern Lake Michigan. However, if you look at the mean annual snowfall map, the longest fetches do not always match the areas that receive the most snowfall. Why is that?



## Fetches & Effective Fetches

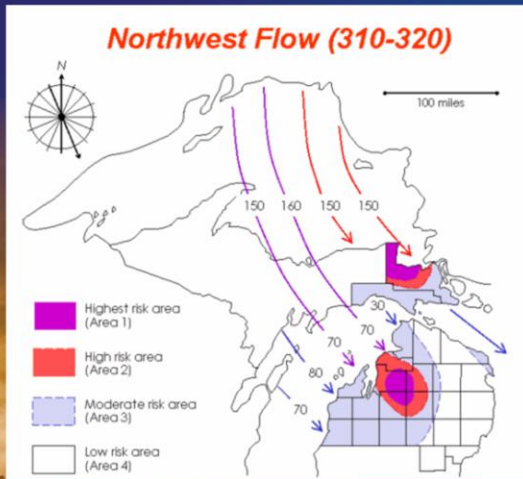
- Yes - there's another lake up there!
- An airmass will retain "lake effect characteristics" on a *short* trip over land, IF there is little terrain (hills/mountains) to cross
- If this is the case, the result is a longer "effective fetch" due to the air crossing multiple lakes

## Fetches & Effective Fetches



- As it turns out, the east half of the U.P. is narrow, and does not have many hills
- The west half is “thicker” and much hillier, and eliminates a Lake Superior contribution to an effective fetch

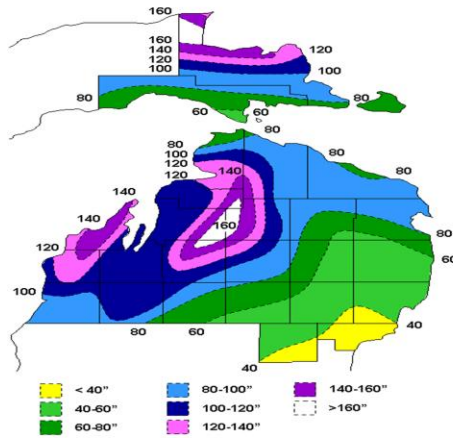
# Fetches & Effective Fetches



- Bingo!
- The longest effective fetch, and heaviest snow, match up nicely.
- In BOTH Peninsulas!

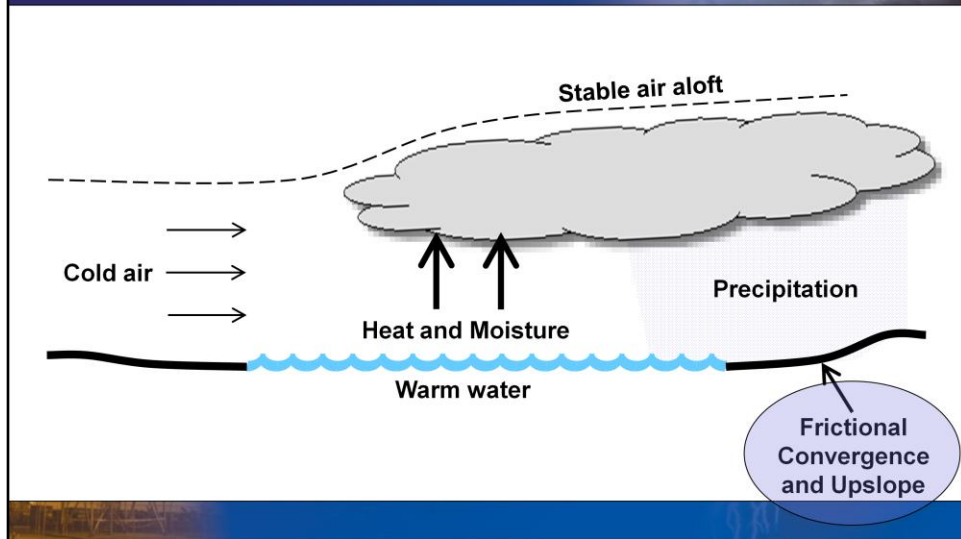
This map shows the total effective fetch when the effects of BOTH lakes are put together. Now, you see a much better correlation between fetch and mean annual snowfall amount. Flow is curved due to the what is in many cases low pressure exiting the region to the north and east.

## Mean Annual Snowfall NWS Gaylord Forecast Area



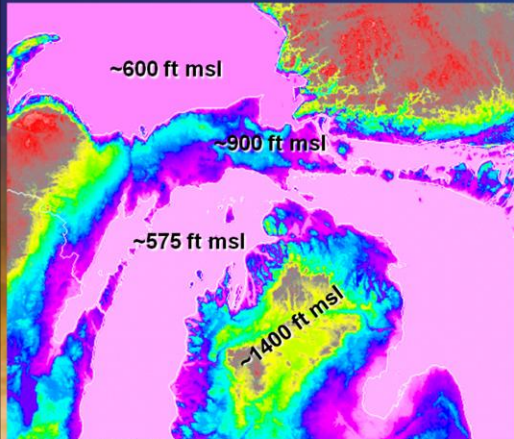
- But why is the heaviest snow inland?
  - It's lake effect; shouldn't it be near the lake?

## Recall How Lake Effect Forms



Recall how lake effect snow forms. Cold air, moving over the relatively warm lake waters is heated and moistened from below. When this warm/moist air reaches the downwind shoreline there is both 1) frictional convergence at the coast and 2) upslope flow over the downstream landmass. The amount of precipitation that falls from the lake induced snow-band will be related to just how much topography this air must rise over.

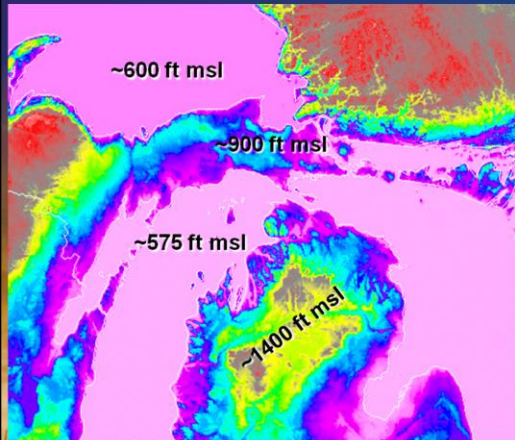
# Elevation



- Elevation plays 2 key roles
  - Forced Ascent
  - Colder Temperatures



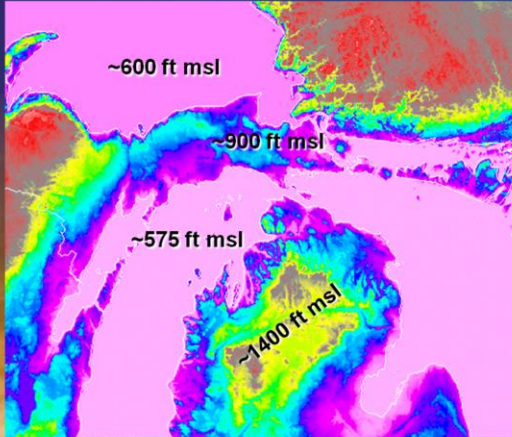
## Elevation – Forced Ascent



- Precipitation will be generated/enhanced when moist/unstable air is forced to ascend
  - They know all about this in the mountain states out west

Our terrain isn't anywhere near as dramatic as out west, BUT our low level airmass is almost always moist and unstable in the late fall/winter, so we get terrain enhancement very frequently.

## Elevation – Colder Temperatures

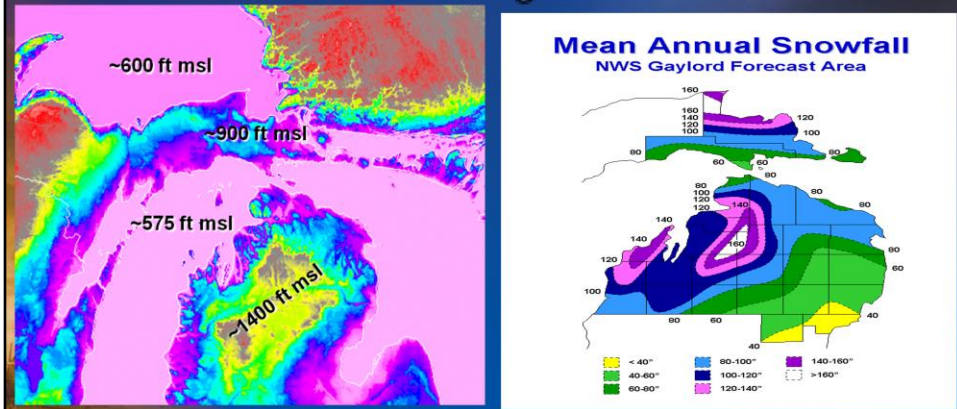


- Top of hills usually colder
- May make the difference between rain and snow

Or, it can make the difference between slushy snow that accumulates poorly (or plain rain), and a drier snow that piles up better.

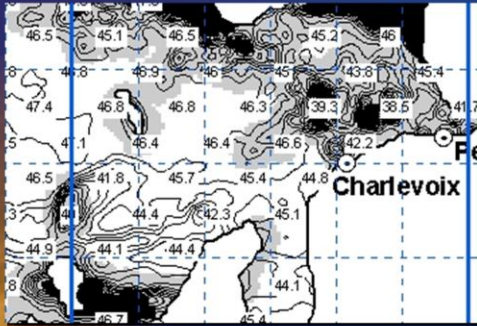
## Elevation

- Conversely, precipitation will diminish/end as air is forced to move *downhill*
- So snow showers will weaken as they move toward NE Lower Michigan and Lake Huron



This is why areas such as Gladwin and Arenac counties do not see much if any lake effect snowfall.

## Elevation & “Warm” Lakes

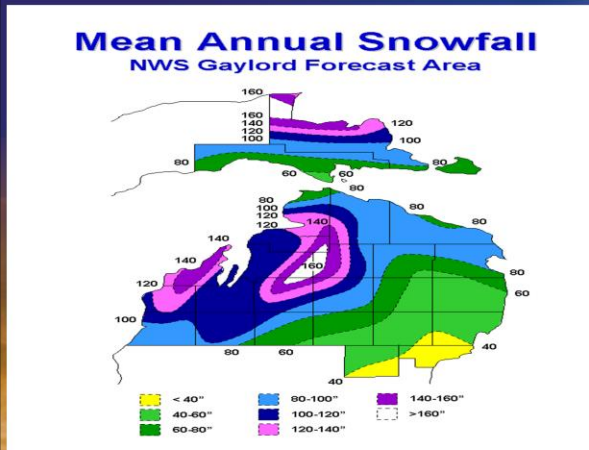


Dec 1 2009

- Most common early in the snow season, when coastal areas will be warmed by the warm lake
  - It's common to see rain in Charlevoix, and snow in Gaylord

The lakes cool down more slowly than the land mass during the fall. In many cases, this yields a “lake-modified” airmass with warmer temperatures near the lake shore versus inland.

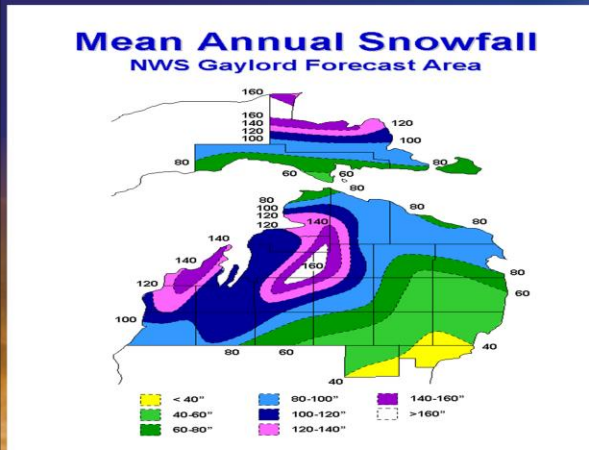
## Elevation & “Warm” Lakes



- Same rules apply to Eastern Upper
- But Superior is colder, and doesn't hinder coastal snow as much as Lake Michigan

Note that the impact isn't as great over Eastern Upper Michigan as Lake Superior is almost always colder than Lake Michigan.

## Elevation & “Warm” Lakes

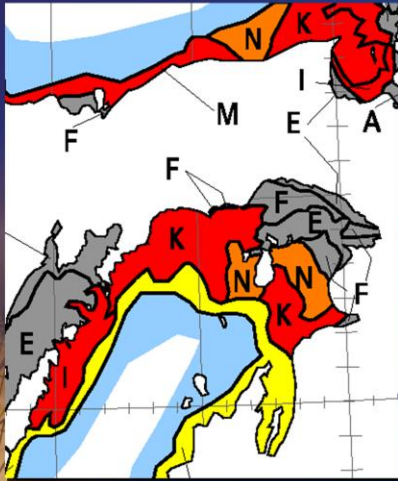


- What about St Ignace?
  - Surrounded by water, but doesn't get much snow
- The prevailing wind is the biggest reason...

Why is St. Ignace in a relative minimum for mean annual snowfall? There are two reasons. First, is the prevailing wind direction and amount of upstream land that any lake effect precipitation must move over. Second is...



## Ice Cover



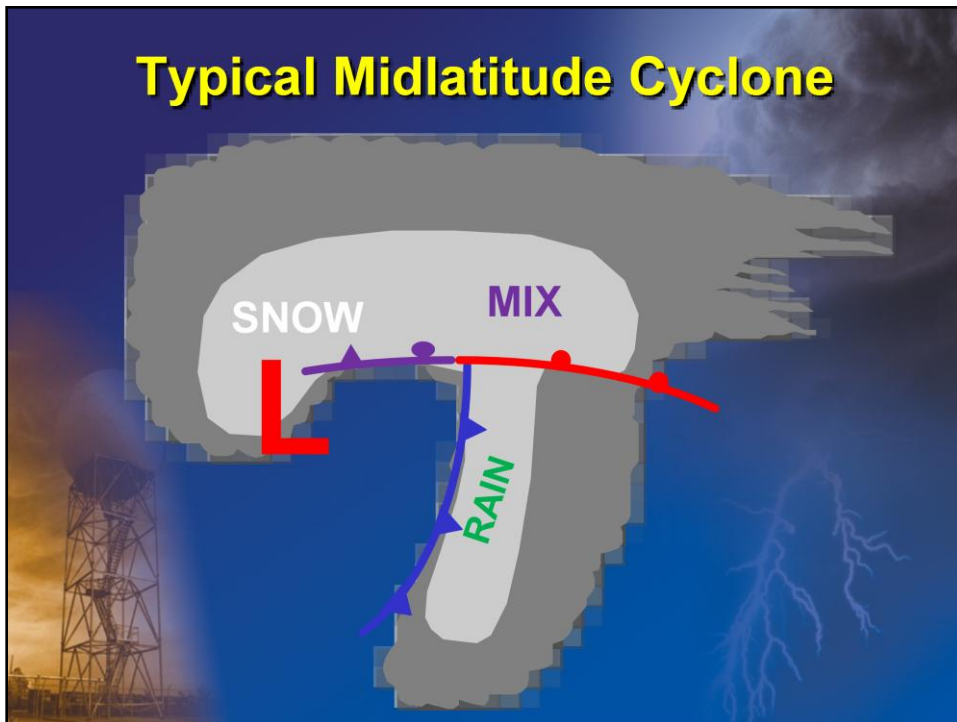
Jan 19 2009

- Ice cover is another reason
- The Straits region freezes over quickly in a typical winter
- Ice-covered water does NOT generate significant lake effect snow

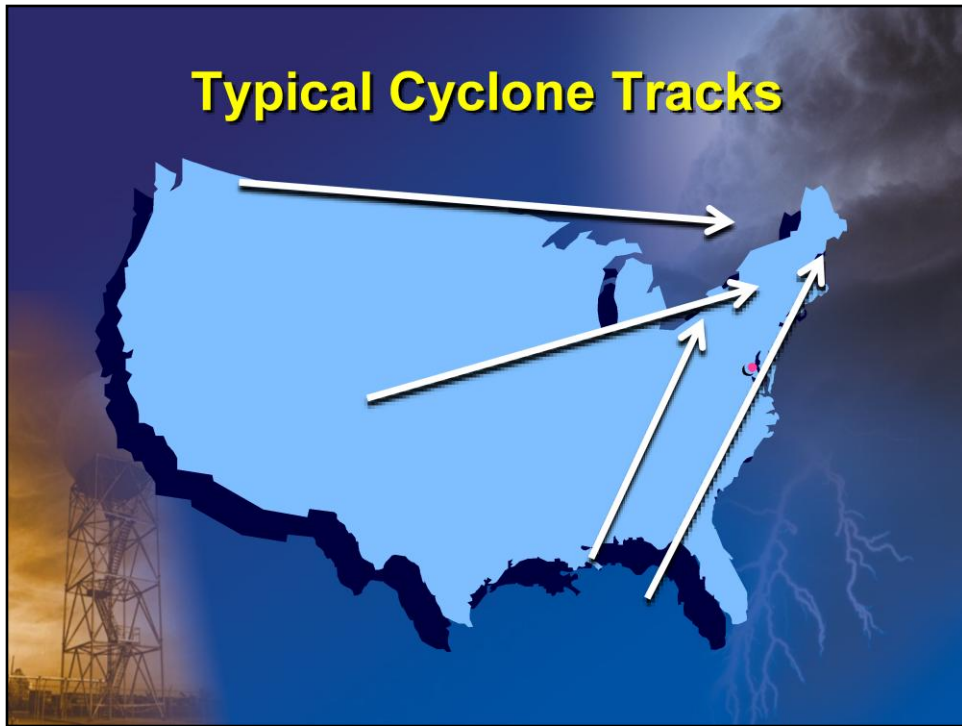
Put another way, the fetches in the Straits area are reduced as ice cover develops and grows.

## The Home Stretch...

- Okay, we now have a handle on lake effect snow and its distribution
- But, what about snow that doesn't originate from the lakes?



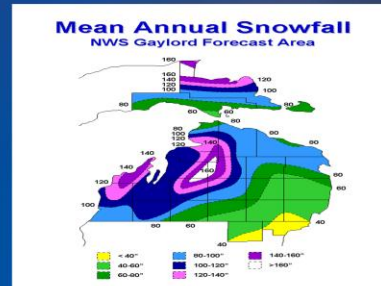
Here is a typical midlatitude cyclone with the primary area of snowfall occurring near and to the north/northwest of the surface cyclone. While rain is seen south of the warm front in the “warm sector”, a wintry mix of precipitation is typically seen north of the warm front.



This map shows typical midlatitude cyclone tracks across the continental United States. There is the Alberta Clipper (farthest north), the Colorado Low, and the east coast Nor'easter.

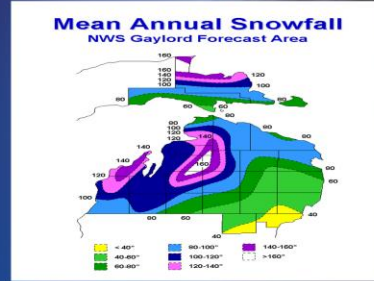
## Midlatitude Cyclone Snow

- Numerous storm tracks pass east or even well east of the region
- If we look at a county that sees relatively little lake effect (e.g. Arenac), we probably can assume a typical “synoptic snowfall”
- ~40 inches per year



Interestingly, many of these storm tracks miss our region to the east, which suggests that if it were not for lake effect snow, we would see less snowfall than many areas over the northeastern United States (which is closer to this storm track). A typical amount of “synoptic” or “system” snow can be seen in Gladwin/Arenac counties (as these areas do not see significant lake effect snow). The amount is about 40” per year.

## In Summary



- Our snow comes from two sources
  - Lake Effect
  - Mid latitude cyclones
- Lake Effect depends on numerous microscale factors
  - Fetch/effective fetch, elevation, lake temperature, ice cover, distance to shore, etc.





**Any Questions???**